

1. A switching device for transferring data packets, comprising:

one or more source line cards each including a request generator to generate a request signal to be transmitted in order to obtain an authorization to transmit data;

one or more destination line cards each including a grant generator to generate and send back a grant signal to a source line card in response to the request signal received at the destination line card to authorize the source line card to transmit a data cell to the destination line card; and

a switching fabric coupled to the source line card and the destination line card, the switching fabric being configured to receive and transmit the request, grant and data cell to the appropriate line cards.

2. The switching device of claim 1, wherein the source line card further includes a data cell transmitter to transmit the data cell upon receiving the grant signal from the destination line card.

3. The switching device of claim 2, wherein the source line card further includes transmit logic to receive a request signal and a data cell which are unrelated to each other on each cell slot from the request generator and data cell transmitter, respectively, and transmit the request signal and the data cell together to the switching fabric.

4. The switching device of claim 2, wherein the source line card further includes transmit logic to receive a grant signal and a data cell which are unrelated to each other on each cell slot from the grant generator and data cell transmitter, respectively, and transmit the grant signal and the data cell

together to the switching fabric.

5. The switching device of claim 1, wherein the source line card further includes transmit logic to receive a request signal and a grant signal which are unrelated to each other on each cell slot from the request generator and grant generator, respectively, and transmit the request signal and the grant signal together to the switching fabric.

6. The switching device of claim 1, wherein the switching fabric includes a plurality of planes, each plane being coupled to the source line card and the destination line card to receive and switch the request signal, the grant signal and the data cell to the appropriate line card.

7. The switching device of claim 1, wherein the switching fabric further includes:

a plurality of first stage crossbars, each first stage crossbar having a plurality of input ports and a plurality of output ports, wherein each of the input ports of the first stage crossbar are connected to a different source line card;

a plurality of second stage crossbars, each second stage crossbar having a plurality of input ports and a plurality of output ports, wherein an i th output port of k th first stage crossbar is connected to a k th input port of the i th second stage crossbar; and

a plurality of third stage crossbars, each third stage crossbar having a plurality of input ports and a plurality of output ports, wherein an i th output port of a k th second stage crossbar is connected to a k th input port of an i th third stage crossbar, wherein each of the output ports of the third stage crossbars are connected to a different destination line card.

8. The switching device of claim 7, wherein each of the first, second and third stage crossbars includes a plurality of request spray engines, each request spray engine associated with one of the input ports of the crossbars, each request spray engine receiving the request signal and spraying the request signal to one of the output ports in the same crossbar to which the request spray engine is associated.

9. The switching device of claim 8, wherein each of the request spray engines includes:

a pointer array having a plurality of pointers, each pointer indexed by a line card and pointing to one of the output ports to where the request signal received is to be transferred;

a jump table having a plurality of pointers to the output ports; and

a control logic to receive the request signal, select the correct pointer in the pointer array to determine which one of crossbars or destination line cards to transfer the request signal, and to replace the selected pointer with a new pointer by indexing the jump table.

10. The switching device of claim 7, wherein each of the first, second and third stage crossbars further includes:

a plurality of grant spray engines, each grant spray engine associated with one of the input ports of the crossbars, each grant spray engine receiving the grant signal and spraying the grant signal to one of the output ports in the same crossbar to which the request spray engine is associated.

11. The switching device of claim 10, wherein each of the grant spray engines includes:

a pointer array having a plurality of pointers, each pointer

indexed by a line card and pointing to one of the output ports to where the grant signal received is to be transferred;

a jump table having a plurality of pointers to the output ports; and

a control logic to receive the grant signal, select the correct pointer in the pointer array to determine which one of crossbars or destination line card to transfer the grant signal, and to replace the selected pointer with a new pointer by indexing the jump table.

12. The switching device of claim 7, wherein each of the first, second and third stage crossbars further includes:

a plurality of data cell spray engines, each data cell spray engine associated with one of input ports of the crossbars, each data cell spray engine receiving the data cell and spraying the data cell to one of the output ports in the same crossbar to which the data cell spray engine is associated.

13. The switching device of claim 12, wherein each of the data cell spray engines includes:

a pointer array having a plurality of pointers, each pointer indexed by a line card and pointing to one of the output ports to where the data cell signal received is to be transferred;

a jump table having a plurality of pointers to the output ports; and

a control logic to receive the data cell, select the correct pointer in the pointer array to determine which one of crossbars or destination line card to transfer the data cell, and to replace the selected pointer with a new pointer by indexing the jump table.

14. The switching device of claim 7, wherein each of the

first, second and third stage crossbars includes a plurality of request handlers, each request handler associated with one of output ports of the crossbars, each request handler receiving the request signal sprayed by any one of the request spray engines in the same crossbar to which the request handler is associated.

15. The switching device of claim 14, wherein each of the request handlers includes:

a counter array having a plurality of rows of counters and a plurality of columns of counters, to maintain a count of the request signals received, wherein the counter array can have a plurality of counters with a nonzero count to indicate there are a plurality of request signals waiting to be transmitted;

a counter controller to increment the counters in the counter array corresponding to the request signals received, and to decrement the counters when they are reconstructed into request signals to be transmitted;

an arbiter to select a counter to be serviced; and

an output logic to reconstruct a request signal for a selected counter.

16. The switching device of claim 15, wherein the request handler further includes first summary bits having a plurality of bits corresponding to a plurality of blocks of counters in a given column in the counter array, the value of each bit indicating whether the corresponding block of counters has a counter that is nonzero in value, so that the arbiter can index the first summary bits to determine which blocks in the given column has counters that are nonzero in value and require to be serviced, wherein the first summary bits are updated whenever a count for any corresponding counter changes.

17. The switching device of claim 16, further including second summary bits having a plurality of bits corresponding to a plurality of blocks, the value of each bit indicating whether the corresponding block has a nonzero counter, so that the arbiter can index the second summary bits to determine which first summary bits have counters that are nonzero in value and require servicing, wherein the second summary bits are updated whenever a count for any corresponding counter changes.

18. The switching device of claim 15, wherein the rows of the counter array and the columns of the counter array represent the destination line card to where the request signal is to be sent and the source line card from where the request signal was received, respectively.

19. The switching device of claim 15, wherein the rows of the counter array and the columns of the counter array represent the source line card from the request signal was received and the destination line card to where the request signal is to be sent, respectively.

20. The switching device of claim 15, wherein the rows of the counter array and the columns of the counter array represent the source line from which the request signal was received and the input port from where the request signal was received, respectively.

21. The switching device of claim 14, wherein each of the request handlers in the third stage crossbars includes:

a counter array having a plurality of rows of counters and a plurality of columns of counters, to maintain a count of the request signals received at the output port associated with the

counter array and need to be transmitted to one of the destination line cards, wherein the rows represent the possible source line cards of the request signal and the columns represent the input ports in the same crossbar to which the counter array is associated;

a counter controller to receive the request signals from any one of the input ports and increment the counters in the counter array corresponding to the request signals received, and to decrement the counters in the counter array corresponding to the request signals that have been reconstructed for transmission to one of the destination line cards;

an arbiter to select the counters in the counter array with nonzero values to reconstruct them into the requests for transmission to one of the destination line cards; and

an output logic to reconstruct the counters selected by the arbiter into the request signals for transmission to one of the destination line cards.

22. The switching device of claim 7, wherein the first, second and third stage crossbars further includes:

a plurality of grant handlers, each grant handler associated with one of the output ports of a crossbar, each grant handler receiving a grant signal sprayed by any one of the grant spray engines in a same crossbar to which the grant handler is associated; and

a plurality of data cell handlers, each data cell handler associated with one of the output ports of a crossbar, each data cell handler receiving a data cell sprayed by any one of the data cell spray engines in a same crossbar to which the data cell handler is associated.

23. In a switching device having a plurality of line cards

and a switch fabric therebetween for transferring data packets, a switch fabric comprising:

a plurality of first stage crossbars in a first stage, each crossbar having a plurality of input ports and a plurality of output ports, each input port having a first request spray engine to receive a request signal and spray the request signal to one of the output ports in the same first stage crossbar;

a plurality of second stage crossbars in a second stage, each crossbar having a plurality of input ports and a plurality of output ports, each input port having a second request spray engine to receive the request signal from one of the first stage crossbars and spray the request signal to one of the output ports in the same second stage crossbar, wherein an i th output port of k th first stage crossbar is connected to a k th input port of i th second stage crossbar; and

a plurality of third stage crossbars in a third stage, each crossbar having a plurality of input ports and a plurality of output ports, each input port having a third request spray engine to receive a request signal from one of the second stage crossbar and spray the request signal to one of the output ports in the same third stage crossbar, wherein an i th output port of second k th stage crossbar is connected to a k th input port of third i th stage crossbar.

24. In a switching device for transferring data packets wherein the switching device includes a plurality of line cards, a line card comprising:

a request generator to generate a request signal to be transmitted to a destination line card in order to receive a grant signal authorizing transferring of data to the destination line card; and

a data cell transmitter to transmit a data cell to the

destination line card upon receipt of the grant signal from the destination card.

25. A switching device for transferring data, comprising:
a destination line card including a grant generator to generate and transmit a grant signal to a source line card to authorize the source line card to transfer data to the destination line card;

the source line card including a data cell transmitter to transfer a data cell to the destination line card upon receiving the grant signal at the source line card;

a switching fabric coupled to the source line card and the destination line card for receiving the grant signal from the destination line card and switching the grant signal to the source line card, and for receiving the data cell from the source line card and switching the data cell to the destination line card.

26. A method for transferring data between line cards in a router, the router having a plurality of line cards and a switching fabric coupled to the line cards, the method comprising:

transmitting a request signal from a source line card to a destination line card through the switching fabric;

upon receiving the request signal at the destination line card, sending a grant signal from the destination line card to the source line card responsive to the request signal to authorize the source line card to transfer data to the destination line card; and

transferring a data cell from the source line card to the destination line card in response to the grant signal received at the source line card.

27. The method of claim 26, wherein the switching fabric includes a plurality of planes, the method further comprising:
transmitting the request signal to one of the planes; and
sending the grant signal from the destination line card to the source line card in response to each of the request signals received at the destination line card from each of the planes.

28. The method of claim 27, further comprising:
sending the grant signal from the destination line card to the same plane from which the request signal arrived.

29. The method of claim 26, wherein the switching fabric is in a three-stage Clos topology having a plurality of first stage crossbars in a first stage, a plurality of second stage crossbars in a second stage and a plurality of third stage crossbars in a third stage, the method further comprising:

transmitting the request signal from the source line card to one of the first stage crossbars;

selecting one of the second stage crossbars to switch the request signal;

switching the request signal to the selected second stage crossbar;

determining which one of the third stage crossbars to direct the request signal according to the destination line card to where the request signal is to be sent;

directing the request signal to the determined third stage crossbar;

determining which one of the line cards coupled to the determined crossbar to transfer the request signal; and

transferring the request signal to the determined line card.

30. The method of claim 29, wherein the selecting step

further comprises:

indexing a first pointer array having a plurality of pointers, each pointer corresponding to one of the possible destination line cards and pointing to one of the second stage crossbars; and

selecting a correct pointer in the first pointer array according to the destination line card to where the request signal is being sent, the selected pointer pointing to one of the second stage crossbars.

31. The method of claim 30, further comprising:

indexing a jump table having a plurality of pointers in a predetermined order, each pointer pointing to one of the second stage crossbars;

reading out a pointer value from the location indicated by the selected correct pointer;

replacing the value of the selected correct pointer in the first pointer array with a value of a pointer within the jump table indicated by the selected correct pointer.

32. The method of claim 29, wherein each of the first stage crossbars has a plurality of output ports, each output port coupled to one of the second stage crossbars, wherein the switching step further includes:

spraying the request signal received at the first stage crossbar from the source destination line card to one of the output ports of the same first stage crossbar, the output port being connected to the selected second stage crossbar;

indexing a counter array associated with the output port to locate a counter in the counter array corresponding to the request signal;

incrementing the located counter to represent the request

signal received at the output port;
selecting the incremented counter;
reconstructing the selected counter into the request signal;
and
transmitting the reconstructed request signal to the
selected second stage crossbar

33. The method of claim 29, wherein determining which one of the third stage crossbars to direct the request signal includes:

indexing a second pointer array having a plurality of pointers, a pointer for each possible destination line card to where the request signal can be sent, each pointer pointing to one of the third stage crossbars to where the request signal is to be sent according to the destination line card to where the request signal is to be sent; and

selecting a correct pointer in the second pointer array according to the destination line card to where the request signal is being sent, the selected pointer pointing to one of third stage crossbars.

34. The method of claim 26, wherein the switching fabric is in a three-stage Clos topology, a plurality of first stage crossbars in a first stage, a plurality of second stage crossbars in a second stage and a plurality of third stage crossbars in a third stage, wherein transferring the data cell from the source line card to the destination line card further comprises:

transmitting the data cell from the source line card to one of the first stage crossbars;

selecting one of the second stage crossbars to where the data cell is to be switched;

switching the data cell to the selected second stage

crossbar;

determining which one of the third stage crossbars to direct the data cell according to the destination line card to where the data cell is to be sent;

directing the data cell to the determined third stage crossbar;

determining which one of the line cards coupled to the determined third stage crossbar to transfer the data cell according to the destination line card to where the data cell is to be sent; and

transferring the data cell to the determined line card.

35. The method of claim 34, wherein switching step further comprises:

storing the data cell received in the first stage crossbar in a memory associated with the input port of the first stage crossbar where the data cell was received;

selecting one of the second stage crossbars to transmit the data cell;

sending a cell pointer which points to the data cell stored in the memory to a cell pointer queue associated with the selected second stage crossbar;

selecting the cell pointer in the cell pointer queue;

requesting the data cell stored in the memory using the cell pointer;

transmitting the data cell from the memory to a cell queue associated with the selected second stage crossbar;

storing the data cell in the cell queue; and

transferring the data cell from the cell queue to the selected second stage crossbar according to the destination line card to where the request signal is being sent.

36. In a switching device having a plurality of line cards and a switch fabric therebetween for transferring data packets, a method for controlling the transfer of data packets through the switching device comprising:

using a same path for data packets as flow control.

37. In a switching device having a plurality of line cards and a switch fabric therebetween for transferring data packets, where each line card includes an input section including one or more input ports and an output section including one or more output ports, a method for controlling the transfer of a data packet through the switching device comprising:

generating a request flow control message at a source line card to request the authorization for a transfer of the data packet from the source line card to the destination line card;

transferring the request flow control message from the input section of the source line card to the output section of the destination line card using the switching fabric;

generating a grant flow control message at a destination line card for the data packet;

transferring the grant flow control message from the output section of the destination line card to the input section of the destination line card;

transferring the grant flow control message from the input section of the destination line card to the output section of the source line card using the switching fabric;

receiving the grant flow control message on the output section of the source line card and transferring the grant flow control message to the input section of the source line card; and

upon receipt of the grant flow control message at the input section of the source line card, transferring the data packet from the source line card to the destination line card using the

switching fabric.

38. In a switching device having a plurality of line cards and a switch fabric therebetween for transferring data packets, where each line card includes an input section including one or more input ports and an output section including one or more output ports, a method for controlling the transfer of a data packet through the switching device comprising:

generating flow control messages at the source line card and destination line card to authorize a transfer of the data packet from the source line card to the destination line card; and

transferring the flow control messages between the source and destination line cards including

transferring flow control messages from the input section of a line card to the output section of a different line card using the switching fabric;

transferring flow control messages from the output section of a line card to the input section of a same line card without using the switching fabric.

39. In a switching device having a plurality of line cards and a switch fabric therebetween for transferring data packets, a method for controlling the transfer of a data packet through the switching device comprising:

generating flow control messages at the source line card and destination line card to authorize a transfer of the data packet from the source line card to the destination line card, each flow control message only including a source and destination line card address; and

transferring the flow control messages between the source and destination line cards using the switching fabric whereby minimal data buffering is required in the switch fabric to fairly

process the flow control messages.

40. In a switching device having a plurality of line cards and a switch fabric therebetween for transferring data packets, a method for controlling the transfer of a data packet received at a source line card to be transferred to a destination line card using the switch fabric, the method comprising:

using a probe cell to arbitrate when the data cell will be transferred including transferring the probe cell from the source line to destination line card using the switch fabric.

41. An apparatus for spraying a data request uniformly across a plurality of output ports comprising:

a jump table;
a next port table where each entry in the next port table is an index to an entry in the jump table;
a spray engine operable to
 receive a data request having a first value of n ,
 determine a value, the k -th value, of the n -th entry in the next port table,
 determine a value, the m -th value, of the k -th entry of the jump table,
 route the request to the k -th output port; and
 write the m -th value to the n -th entry of the next port table.

42. A switching device for transferring data packets, comprising:

one or more source line cards each including a request generator to generate a request signal to be transmitted in order to obtain an authorization to transmit data;

one or more destination line cards each including a grant

generator to generate and send back a grant signal to a source line card in response to the request signal received at the destination line card to authorize the source line card to transmit a data cell to the destination line card; and

a plurality of switching planes coupling the source line cards and the destination line cards, each switching plane being configured to receive and transmit the request, grant and data cell to the appropriate line cards.

43. In a switching device including one or more source line cards and destination line cards, the switching device for transferring data packets through a network, a method for recovering from a failure in the switching device comprising:

providing plural switching planes between each source line card and destination line card;

generating flow control messages for authorizing a transfer of a packet from a source line card to a destination line card;

spraying the flow control messages over each of the plural switching planes;

spraying data packets over switching planes on which flow control authorization messages are received.